IN THE UNITED STATES PATENT & TRADEMARK OFFICE
Before the Primary Examiner

In re Application of: )
RAYMOND S. ROBINSON ET AL. ) Group Art Unit: 1753
Serial No. 09/881,116 )
Filed: June 13, 2001 ) Examiner: R.D. McDonald
For: SPUTTER DEPOSITION USING MULTIPLE TARGETS

Attorney Docket No. 353-08

Hon. Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF HAROLD R. KAUFMAN

HAROLD R. KAUFMAN, being duly sworn, deposes and states as follows:

1. I am one of the named inventors in the above-identified application.

2. I have read the Office Action mailed September 24, 2003 and the references cited by the Examiner.

3. I am quite familiar with the ion source used by Ceasar et al. in U. S. Patent No. 4,376,688 and by Cuomo et al. in U.S. Patent 4,250,009. In each of those patents the ion source is described as a Kaufman ion source. Cuomo et al. specifically refer to the source as a "standard Kaufman ion source" of the variety discussed in a chapter entitled "Ion Beam Deposition" by J.M.E. Harper in the book entitled *Thin Film Processes*.

4. I am the inventor of the "Kaufman ion source" referred to by the Ceasar et al. and Cuomo et al. patents. The "Kaufman ion source" is described in U.S. Patent No. 3,156,090 where the

range of operation is given as "one to several thousand volts" (col. 4, lines 19-22). As can be understood by examining the rest of the patent, this means one thousand to several thousand volts, or, for singly charged ions, one thousand to several thousand eV.

5. The Examiner is in error in contending that the ion source used by Ceasar et al. can operate at approximately 50 eV or less. The range of operation for Kaufman ion sources is given by Harper on page 181, Chapter II-5 of *Thin Film Processes* as 500-2000 eV. The lower limit (i.e. 500 eV) stated by Harper as compared to 1000 eV stated in the Kaufman '090 patent is due to detailed improvements in ion optics (i.e. smaller grid apertures and spacing).

6. The range of operation for a Kaufman ion source used by Cuomo et al. is several hundred eV to several thousand eV (see col. 4, lines 31-36 and lines 47-50, noting that the ion energy in eV equals the beam voltage in volts for singly charged ions).

7. Although the Ceasar et al. patent mentions in his Summary of the Invention that beam energy can range from "0 to about 2000 eV", this is a very general statement. The example illustrated by Ceasar et al. cites a beam energy of 500 eV (col. 7, line 67 to col. 8, line 2). None of the claims in the patent specify a low energy ion beam. Further, Ceasar et al.

does not describe biasing the target negative relative to ground, nor do Ceasar et al. describe multiple targets.

8. Because I am very familiar with the operation of the ion sources described by Ceasar et al., I can state with confidence that such ion sources, operated in the manner described by Ceasar et al., would not be capable of operating at ion beam energies less than 50 eV. If the user is prepared to accept greatly reduced ion currents, it may be possible to reduce the ion energy to 200-300 eV, or perhaps even to 100 eV, but operation is neither practical nor possible with this type of source at or under 50 eV. With regard to being practical, the ion beam current drops so rapidly with voltage that operation of this type of source below several hundred eV is seldom considered (see Harper in the above-mentioned *Thin Film Processes* where he gives the ion energy range for a Kaufman source as 500-2000 eV, and see Cuomo et al., col. 7, lines 47-50). Also, this type of source becomes unstable when operation is attempted at a beam voltage approaching the discharge voltage (given as 50 V by Harper and by Ceasar et al., col. 8, lines 33-36). When Ceasar et al. cite the range as 0-2000 eV, they are not interested in the extreme low energy part of this range (see col. 6, lines 31-33) nor were they correct in their description (see Harper and Cuomo et al.). This is why I respectfully disagree with the Examiner's interpretation of Ceasar et al. as teaching operation under 50 eV.

9. Further, both the Ceasar et al. patent and the Cuomo et al. patent describe high energy ion-beam sputtering processes which require that an ion beam be directed at the target. Please note that this does not mean that the ion beam is directed at the target and surrounding hardware in a general and diffuse manner. The ion beam must both be directed at the target and not strike surrounding hardware in order to generate a film of target material that is not contaminated with impurities sputtered from other hardware. The Kaufman ion source is used in ion-beam deposition because the electrostatic acceleration between grids is known by those skilled in the art to produce a well-defined and directed ion beam. The ion beam can be either collimated (generated by flat grids) or it can be focused (generated by spherically shaped grids having their concave sides facing the target). The well-defined ion beams shown in Fig. 1 of Ceasar et al., and Fig. 4 of Cuomo et al., are generally correct. There are, however, a few energetic "stray" ions that are outside of the ion beams indicated. If very high purity is required for the deposited film, it may be helpful to use a shield between the ion source and the target to intercept most of these stray ions, as described by Ceasar et al. in col. 7, lines 37-52.

10. The Baldwin et al. patent refers to a method for controlling deposition thickness using a rotating substrate.

Such patent does not describe use of an ion source having an energy of 50 eV or less.

11. The Kanda et al. patent refers to the use of a plurality of ion beam sources and a plurality of sputter targets. This patent does not describe use of an ion source having an energy of 50 eV or less.

12. I am a named inventor of U.S. Patent No. 4,862,032, cited by the Examiner. Such patent describes an end-Hall ion source. The statement in the patent regarding a "high-current, low-energy ion beam source" was a reference to that source being a new type of ion source characterized by the ability to produce large currents of low energy ions as compared to the prior art gridded ion sources (the "Kaufman" ion sources described by Ceasar et al., Cuomo et al., and Harper). Also in distinction to the prior art gridded sources, the end-Hall ion source produces a broad, poorly defined ion beam--see Kaufman '032, Figs. 6 and 7, col. 7, lines 55-57. The broad ion beam produced by this source is a result of two contributions. Electromagnetic acceleration (used in the end-Hall source) is less precise in controlling ion trajectories than electrostatic acceleration (used in the gridded Kaufman ion sources). Also, low-energy ion beams, due to the electron energy therein being significant compared to the ion energy, are inherently more difficult to direct into collimated or focused ion beams. There is no description in the '032 patent of sputtering deposition

apparatus as used in the present invention in which (a) the ions have an energy of about 50 eV or less, and (b) targets which are biased negative relative to ground. Further, the poorly defined nature of the ion beam would not permit the end-Hall source to be used in the apparatus of Ceasar et al.

13. Combination of the teachings of the Ceasar et al. and Cuomo et al. references would not lead to the present invention where sputtering is achieved, without contamination, at an energy of about 50 eV or less without a need for focusing the ion beam or using a shield. A fair reading of the cited references shows that they utilize much higher energies than the present invention, and that the ions must be directed at the target, and not elsewhere. We have avoided those requirements in our invention.

14. The cited patents do not describe the methods claimed in our present application. Combination of the teachings of such patents would not lead to our claimed methods which require use of (a) an ion source producing ions having an energy of about 50 eV or less, and (b) a plurality of targets biased negative relative to ground. In the present invention the ion source provides low energy ions which are accelerated toward the target, and reach an energy sufficient to sputter target material, by biasing the target negative relative to ground. Any ions which miss the target do not have sufficient energy to sputter the hardware; therefore, contamination of the

deposited film is minimized without directing the ion beam at the target. Low energy ion beams, by their very nature, are difficult to direct into collimated or focused beams.

15. The present invention is fundamentally different from the apparatus and methods described in the prior patents. The Cuomo et al. and Ceasar et al. patents do not describe apparatus or methods in which a low energy ion beam is caused to strike a target which is biased negative relative to ground. Although the Cuomo et al. patent mentions biasing a target, the bias is for the purpose of selecting negative and positive ions--it is not for the purpose of increasing sputtering.

16. Attempts to combine the features of the patents cited in the Office Action would not result in the apparatus or methods of the present invention because none of the cited patents show the feature of biasing the target negative relative to ground for the stated purpose of increasing ion energy. Consequently, even if one were to attempt use of Ceasar's device at low energy, with a grounded target which Ceasar shows, useful sputtering of a target would not be obtained. The prior patents do not show or recognize the significance of the use of low energy in the manner of the present invention.

17. The collective teachings of the cited patents would suggest that low energy sputtering cannot be performed. None of the cited patents show increasing ion energy by biasing the

target negative relative to ground for the purpose of increasing the ion energy to reach the level of energy required to obtain sputtering. Further, nowhere do the cited patents teach the increase of the energy of ions in an ion beam from a low level to a level above the sputter threshold. When using an ion source which produces high energy ions, there are always some stray ions which miss the sputter target. Such ions will cause contamination in the deposited film. The present invention avoids this problem in a unique manner by using ions from the ion source having an energy less than or equal to the sputtering threshold.

18. I affirm that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or documents or any patent resulting therefrom.

Harold R. Kaufman

HAROLD R. KAUFMAN

Date: December 23, 2003